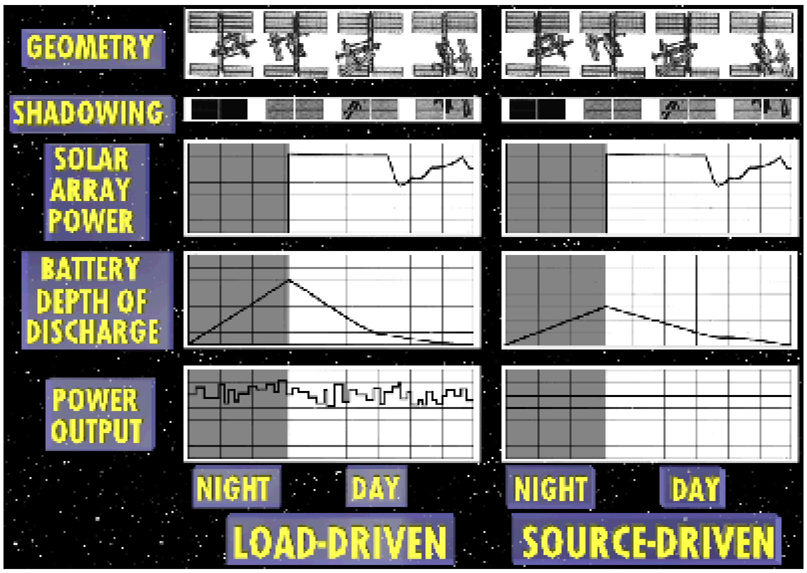
Advanced Power System Analysis Capabilities

As a continuing effort to assist in the design and characterization of space power systems, the NASA Lewis Research Center's Power and Propulsion Office developed a powerful computerized analysis tool called System Power Analysis for Capability Evaluation (SPACE). This year, SPACE was used extensively in analyzing detailed operational timelines for the International Space Station (ISS) program.

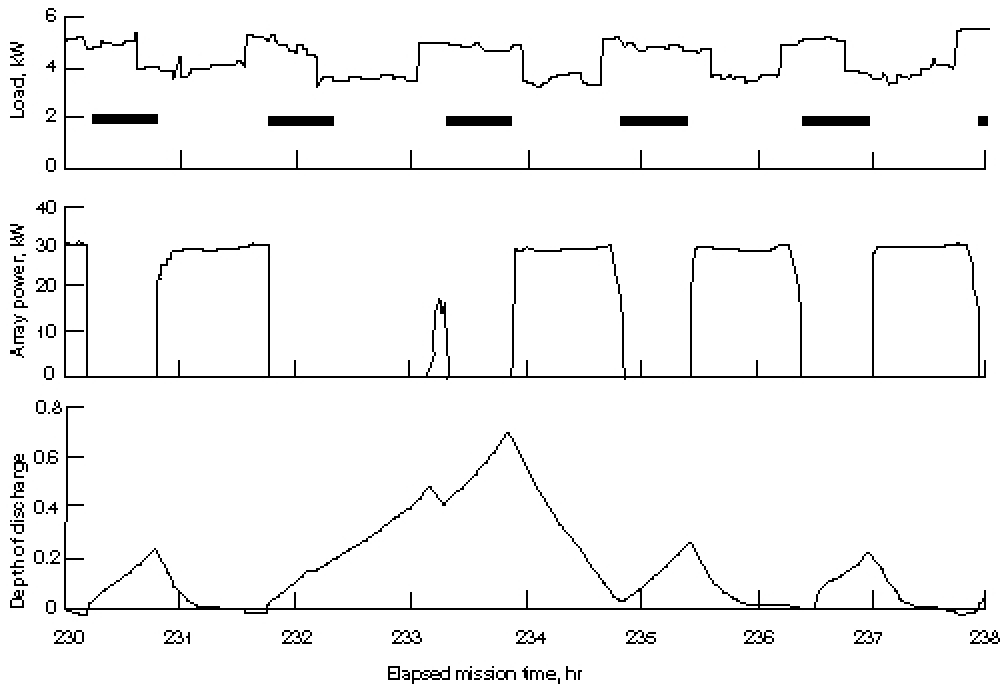
SPACE was developed to analyze the performance of space-based photovoltaic power systems such as that being developed for the ISS. It is a highly integrated tool that combines numerous factors in a single analysis, providing a comprehensive assessment of the power system's capability. Factors particularly critical to the ISS include the orientation of the solar arrays toward the Sun and the shadowing of the arrays by other portions of the station (refs. 1 and 2).



Two types of power system analysis capabilities.

The figure above shows two types of analyses that can be performed with SPACE. A source-driven analysis (refs. 3 and 4) determines the highest power level that can be sustained over an orbit. This information is critical during the design phase for sizing system components and determining power available for experiments. A load-driven analysis (ref. 5) assesses the ability of the system to supply a specific time-varying power demand. This type of analysis is important in the operational phase for validating the interworkings of various systems.

The following figure, an example of the analysis currently being performed for the ISS program, shows part of a 2-week assembly mission. During this period (around shuttle separation), the orientation of the station is constantly changing. The dark bars show when the station is shadowed by the Earth. The three curves show the power demand, solar array power, and battery depth of discharge for one representative power channel. Battery depth of discharge is a measure of the energy removed from the batteries in comparison to their energy capacity. During the example analysis period, the solar array power drops, requiring more energy to be drawn from the batteries, resulting in a higher depth of discharge.



Typical analysis output for load-following case. Top: Load demand. Middle: Available array power. Bottom: Battery depth of discharge.

In this example, the depth of discharge reached a relatively high level. However, the mission was still viable, since no hardware limits were exceeded, and the batteries were not fully drained. However, this may not be true for all assessments. The model might detect hardware limit violations or predict that the battery depth of discharge reaches 100 percent. At 100-percent depth of discharge, the battery is completely drained, and an unacceptable "blackout" occurs. Simpler power system models that do not account for all the factors that affect the power system would not be able to accurately predict these conditions.

Although its primary use has been to support the ISS program, SPACE has many other potential uses. It can be enhanced to analyze other power systems, including space- and ground-based systems. It could also be used as a basis for "smart" power systems with fault and failure prediction, diagnosis, and recovery tools or as an addition to other satellite analysis software. SPACE represents the synthesis of over 10 years of power system analysis expertise and software development, validation, and verification. It performs detailed, integrated performance analysis of power systems to determine optimum power capability and operation.

For more information about this research, visit the Power and Propulsion Office, or look at our SPACE model.

References

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